VAPOR PHASE GROWTH APPARATUS AND
METHOD OF FABRICATING EPITAXIAL WAFER

BACKGROUND OF THE INVENTION

5   [Field of the Invention]

This invention relates to a vapor phase growth apparatus
allowing vapor phase growth of a silicon single crystal film on the
main surface of a silicon single crystal substrate to proceed therein,
10   and a method of fabricating an epitaxial wafer realized using the
same.

[Description of the Related Art]

15   Silicon epitaxial wafer having a silicon single crystal film
(simply referred to as "film", hereinafter) grown in vapor phase on
the main surface of a silicon single crystal substrate (simply
referred to as "substrate", hereinafter) is widely used for electronic
devices such as bipolar IC, MOS-IC and so forth.   With
20   advancement in micronization of the electronic devices,
requirement for flatness of the main surface of the epitaxial wafer in
which the devices are fabricated has been becoming more stringent.
Causal factors affecting the flatness include flatness of the
substrate and distribution of the film thickness.   In recent years,
25   single-wafer-type vapor phase growth apparatus has become a

mainstream in fabrication of epitaxial wafers having a diameter of 200 mm or more, in place of batch processing of a plurality of wafers. The apparatus holds a single substrate in a horizontally rotating manner in a reaction vessel, while allowing a source gas to

5 flow from one end to the other end of the reaction vessel in a horizontal and unidirectional manner, to thereby proceed vapor phase growth of the film.

One important factor in view of making the resultant film

10 thickness uniform in the above-described single-wafer-type vapor phase growth apparatus is flow rate, or flow rate distribution of the source gas in the reaction vessel. The single-wafer-type vapor phase growth apparatus is generally configured as introducing the source gas through a gas supply duct and through a gas introducing

15 port formed on one end of the reaction vessel, allowing the source gas to flow along the surface of a substrate, and discharging the source gas through a discharging port on the other end of the vessel. In order to reduce non-uniformity in the flow rate in thus-configured vapor phase growth apparatus, proposals have

20 been made on an apparatus having a dispersion plate with a large number of through holes formed therein, disposed on the downstream side of the gas introducing port, and an apparatus having disposed therein a partition plate partitioning the gas flow in the width-wise direction.

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Japanese Laid-Open Patent Publication "Tokkaihei" No. 7-193015 discloses a configuration of an apparatus allowing the source gas supplied through the gas introducing port to flow towards the outer peripheral surface of a bank component disposed around a susceptor holding a substrate, so as to supply the source gas onto the surface of a substrate after climbing up the bank component.   A basic concept of this method is to diffuse the source gas by allowing the flow thereof to collide against the outer peripheral surface of the bank component, to thereby resolve non-uniformity in the flow rate.   Another proposal has been made on this sort of vapor phase growth apparatus having the bank component improved so as to allow the source gas to flow more smoothly towards the susceptor (Japanese Laid-Open Patent Publication "Tokkai" No. 2002-231641).   Still another proposal has been made on the vapor phase growth apparatus improved so as to intentionally make variation in the flow of the source gas on both sides of the susceptor (Japanese Laid-Open Patent Publication "Tokkai" No. 2002-198316).

Typical known problems in the vapor phase epitaxial growth of the silicon single crystal film on the silicon single crystal substrate include deformation of patterns.   Several factors affecting the pattern deformation have been known, wherein the degree of pattern deformation can be reduced generally by lowering pressure in the reaction vessel so as to increase a diffusion

coefficient of HCl gas produced on the surface of the substrate, to thereby depress the etching action by the HCl gas. For this reason, a reduced pressure condition is preferably applied to vapor phase growth on the silicon single crystal substrate having patterns

5 already formed thereon.

Epitaxial growth under a reduced pressure condition using the apparatus such as described in the aforementioned Japanese Laid-Open Patent Publication "Tokkaihei" No. 7-193015 may,

10 however, sometimes encounter a difficulty in obtaining a desired distribution of film thickness.

It is therefore an object of this invention to provide a vapor phase growth apparatus capable of uniformalizing the flow route of

15 the source gas flowing over the silicon single crystal substrate, and a method of fabricating an epitaxial wafer using the same, aiming at ensuring a desirable distribution of film thickness.

Patent Document 1: Japanese Laid-Open Patent Publication "Tokkaihei" No. 7-193015;

20 Patent Document 2: Japanese Laid-Open Patent Publication "Tokkai" No. 2002-231641; and

Patent Document 3: Japanese Laid-Open Patent Publication "Tokkai" No. 2002-198316.

25 SUMMARY OF THE INVENTION

In the vapor phase growth apparatus configured as disclosed in the above documents, a gas introducing gap 60', as indicated by the hatched line in FIG. 8, is formed by a bank

5   component surrounding a susceptor and an upper lining component disposed right above the bank component. On the other hand, the source gas G introduced into the vapor phase growth apparatus tends to flow so as to minimize as possible the frictional resistance. As it can be understood from FIG. 8, assuming now that source gas

10   G flows nearly in parallel with the horizontal standard line HSL, the source gas G flows across a longer path of the gas introducing gap 60' at a position more largely distant from the horizontal standard line HSL. The stream of the source gas G flowing more largely distant from the horizontal standard line HSL, therefore, tends to

15   inwardly deflect the direction of flow to a larger degree, in the vicinity of an exit of the gas introducing gap 60'. This is one cause for raising difficulty in uniformalizing the flow route of the source gas flowing over the silicon single crystal substrate.

20   The present inventors having been aware of this problem went through extensive investigations, to finally complete this invention described below. That is, a vapor phase apparatus of this invention is a vapor phase growth apparatus allowing vapor phase growth of a silicon single crystal film on the main surface of a

25   silicon single crystal substrate to proceed therein, having a reaction

vessel having a gas introducing port formed on a first end side in the horizontal direction, and having a gas discharging port on a second end side in the same direction, configured as allowing a source gas for forming the silicon single crystal film to be introduced

5 through the gas introducing port into the reaction vessel, and to flow along the main surface of the silicon single crystal substrate held in a near-horizontally rotating manner in the inner space of the reaction vessel, and to be discharged through the gas discharging port, the silicon single crystal substrate being disposed on a

10 disc-formed susceptor rotated in the inner space, and having a bank component disposed so as to surround the susceptor, and kept in a positional relation so as to align the top surface thereof at an almost same level with the top surface of the susceptor, further configured so that the gas introducing port is opened so as to oppose to the

15 outer peripheral surface of the bank component, so as to allow the source gas supplied through the gas introducing port to collide against the outer peripheral surface of the bank component and to climb up onto the top surface side thereof, and then to flow along the main surface of the silicon single crystal substrate on the

20 susceptor, and further comprising an upper lining component disposed so as to hang over the bank component, while forming a gas introducing gap communicated with the reaction vessel by the bank component and the upper lining component; wherein, assuming a virtual center line along the direction of flow of the

25 source gas, extending from the first end of the reaction vessel

towards the second end, while crossing normal to the axis of rotation of the susceptor, as the horizontal standard line, and also assuming the direction normal to both of the axis of rotation of the susceptor and the horizontal standard line as the width-wise

5   direction, the gas introducing gap is configured so that the length-to-be-formed thereof in the parallel direction with the horizontal standard line is decreased in a continuous or step-wise manner as distanced from the horizontal standard line in the width-wise direction, or remained constant at any position.

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The vapor phase growth apparatus of this invention is such as forming a flow passageway of the source gas, flowing up over the susceptor disposed in the reaction vessel, by the bank component (lower liner) and the upper lining component (upper liner).   As

15   described in the above, the source gas flowing through the apparatus tends to flow while selecting a position where the frictional resistance can be minimized as possible.   The vapor phase growth apparatus of this invention is adjusted so as to decrease the length of the gas introducing gap as distanced from

20   the horizontal standard line in the width-wise direction, or remained constant at any position.   The flow of the source gas is, therefore, prevented from largely changing from the direction of the horizontal standard line, where distanced from the horizontal standard line. As a consequence, a vapor phase growth apparatus capable of

forming a silicon single crystal film having a desirable thickness distribution can be realized.

In one preferred embodiment, the above-described vapor

5 phase growth apparatus may be configured so that the degree of overlapping, in the vertical direction, of the top surface of the bank component forming the gas introducing gap and the lower surface of the lining component forming the same is reduced as distanced from the horizontal standard line in the width-wise direction, or

10 remained constant at any position.   This configuration allows adjustment of the length-to-be-formed of the gas introducing gap through adjustment of the degree of overlapping between the bank component and the upper lining component, and is therefore readily adaptive to any changes in design and so forth.

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The inner periphery of the lower surface of the upper lining component may be located on the upstream side, in the direction of flow of the source gas, rather than on the inner periphery of the top surface of the bank component.   It is necessary for the source gas

20 to flow over the top surface of the bank component, and to be smoothly guided onto the top surface of the susceptor.   According to the above-described configuration, the end of the gas introducing gap can be fixed at the position of the inner periphery of the lower surface of the upper lining component, so that the

25 length-to-be-formed of the gas introducing gap can be adjusted

while ensuring smooth guidance of the source gas onto the top surface of the susceptor.

It is also desirable that the vapor phase growth apparatus is configured so that, on the exit side of the gas introducing gap, the center of an arc drawn by the inner periphery of the top surface of the bank component coincides with the axis of rotation of the susceptor, and so that the center of an arc drawn by the inner periphery of the lower surface of the upper lining component is set on the downstream side, in the direction of flow of the source gas, rather than on the axis of rotation of the susceptor, and so that the radius of the arc drawn by the inner periphery of the lower surface of the upper lining component is set larger than the radius of arc drawn by the inner periphery of the top surface of the bank component. These features can conceptually be illustrated in FIG. 7. The hatched portion in FIG. 7 expresses a region of formation of the gas introducing gap. That is, the above-described configuration more specifically shows a configuration in which the length-to-be-formed of the gas introducing gap (the length-to-be-formed in the direction along the horizontal standard line HSL) is gradually reduced as distanced from the horizontal standard line HSL.

The vapor phase growth apparatus of this invention as viewed from another viewpoint is a vapor phase growth apparatus

allowing vapor phase growth of a silicon single crystal film on the

main surface of a silicon single crystal substrate to proceed therein,

having a reaction vessel having a gas introducing port formed on a

first end side in the horizontal direction, and having a gas

5   discharging port on a second end side in the same direction,

configured as allowing a source gas for forming the silicon single

crystal film to be introduced through the gas introducing port into

the reaction vessel, and to flow along the main surface of the silicon

single crystal substrate held in a near-horizontally rotating manner

10   in the inner space of the reaction vessel, and to be discharged

through the gas discharging port, the silicon single crystal substrate

being disposed on a disc-formed susceptor rotated in the inner

space, and having a bank component disposed so as to surround

the susceptor, and kept in a positional relation so as to align the top

15   surface thereof at an almost same level with the top surface of the

susceptor, further configured so that the gas introducing port is

opened so as to oppose to the outer peripheral surface of the bank

component, so as to allow the source gas supplied through the gas

introducing port to collide against the outer peripheral surface of the

20   bank component and to climb up onto the top surface side thereof,

and then to flow along the main surface of the silicon single crystal

substrate on the susceptor, and further having an upper lining

component disposed so as to hang over the bank component, while

forming a gas introducing gap communicated with the reaction

25   vessel by the bank component and the upper lining component;

configured so that the inner periphery of the lower surface of the upper lining component is located on the upstream side, in the direction of flow of the source gas, rather than the inner periphery of the top surface of the bank component, so that, on the exit side of

5   the gas introducing gap, the center of an arc drawn by the inner periphery of the top surface of the bank component coincides with the axis of rotation of the susceptor, and so that the center of an arc drawn by the inner periphery of the lower surface of the upper lining component is set on the downstream side, in the direction of flow of

10   the source gas, rather than the axis of rotation of the susceptor, and so that the radius of the arc drawn by the inner periphery of the lower surface of the upper lining component is set larger than the radius of the arc drawn by the inner periphery of the top surface of the bank component.

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As described in the above, the source gas flowing through the apparatus tends to flow while selecting a position where the frictional resistance can be minimized as possible.   An essential portion of the vapor phase growth apparatus of this invention can

20   conceptually be illustrated in FIG. 7.   The hatched portion in FIG. 7 expresses an area of formation of the gas introducing gap.   It is assumed now that a virtual center line along the direction of flow of the source gas G, extending from the first end of the reaction vessel towards the second end, while crossing normal to the axis of

25   rotation O of the susceptor as the horizontal standard line HSL, and

that the direction normal to both of the axis of rotation O of the susceptor and the horizontal standard line HSL as the width-wise direction WL.   Because radius R_3 of an arc drawn by the inner periphery 40p of the lower surface of the upper lining component is

5   set larger than radius R_1 of an arc drawn by the inner periphery 23p of the top surface of the bank component, the length-to-be-formed of the gas introducing gap with respect to the direction along the horizontal standard line HSL is prevented from increasing as distanced from the horizontal standard line HSL.   The source gas G,

10   therefore, does not largely vary the direction of flow even at a position distant from the horizontal standard line HSL.   This is because the source gas G flowing in the gas introducing gap tends to flow along a route minimizing the resistance, that is, along a route on which the gas introducing gap has a short path.   As a

15   consequence, the source gas enables to flow even more uniformly also around the outer periphery of the susceptor.   In other words, non-uniformity in the flow route of the source gas on the substrate can be dissolved, and thereby a vapor phase growth apparatus capable of forming a silicon single crystal film with a desirable

20   thickness distribution can be realized.

It is also possible to provide the vapor phase growth apparatus with an evacuation system keeping the inner space of the reaction vessel under a reduced pressure lower than the

25   atmospheric pressure.   This configuration allows epitaxial growth

under a reduced pressure condition contributive to reduction in the degree of pattern deformation, when it is desired to proceed the vapor phase growth on a substrate having patterns already formed thereon.

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A method of fabricating an epitaxial wafer of this invention is such as disposing the silicon single crystal substrate in the reaction vessel of the above-described vapor phase growth apparatus, and allowing the source gas to flow in the reaction vessel so as to

10   epitaxially grow a silicon single crystal film on the silicon single crystal substrate in a vapor phase, to thereby obtain an epitaxial wafer.

The silicon single crystal film can epitaxially be grown on the

15   silicon single crystal substrate in vapor phase, by using any one gas selected from the group consisting of monochlorosilane gas, dichlorosilane gas and trichlorosilane gas as the source gas for the vapor phase epitaxial growth, while keeping the inner space of the reaction vessel under a reduced pressure lower than the

20   atmospheric pressure.

It is also preferable to set the degree of opening of an inner valve regulating flow rate of the source gas flowing closer to the horizontal standard line, and an outer valve regulating flow rate of

25   the source gas flowing more distant from the horizontal standard

line, corresponding to the length-to-be-formed of the gas

introducing gap in the direction in parallel with the horizontal

standard line. According to this configuration, any non-conformity

in the flow rate of the source gas over the substrate can be reduced,

5   as a result of synergistic effect of the above-described configuration

of the vapor phase growth apparatus of this invention.

It is denoted herein that the top surface of the bank

component is in an almost coincident positional relation with the top

10   surface of the susceptor. This does not always mean that the top

surface of the bank component and the top surface of the susceptor

are aligned perfectly at the same level, and instead means that

positional difference up to 2 mm or around is acceptable.

15   BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional side elevation showing an example of

the vapor phase growth apparatus of this invention;

FIG. 2 is an enlarged sectional view showing an essential

20   portion of the vapor phase growth apparatus of this invention;

FIG. 3 is a plan view of the vapor phase growth apparatus of

this invention;

FIG. 4 is an exploded perspective view showing, in a partially

cut-off manner, an essential portion of the vapor phase growth

25   apparatus of this invention;

FIG. 5 is a bottom plan view of the upper lining component;

FIG. 6A is a sectional view taken along line 6A-6A containing the horizontal standard line HSL shown in FIG. 5, for explaining a mode of formation of the gas introducing gap;

5 FIG. 6B is a sectional view taken along line 6B-6B shown in FIG. 5, for explaining a mode of formation of the gas introducing gap;.

FIG. 6C is a sectional view taken along line 6C-6C shown in FIG. 5, for explaining a mode of formation of the gas introducing

10 gap;

FIG. 7 is a projected plan view showing an area of formation of the gas introducing gap;

FIG. 8 is a drawing explaining operation of a conventional vapor phase growth apparatus not improved in the upper lining

15 component;

FIG. 9 is a schematic drawing showing another embodiment having a constant length-to-be-formed of the gas introducing gap;

FIG. 10A is a drawing showing a flow route distribution of the source gas in the vapor phase growth apparatus of this invention,

20 obtained by a computer simulation;

FIG. 10B is a drawing showing a flow route distribution of the source gas in a conventional vapor phase growth apparatus, obtained by a computer simulation;

FIG. 11A is a contour map showing a growth rate distribution in the vapor phase growth apparatus of this invention, obtained by a computer simulation; and

FIG. 11B is a contour map showing a growth rate distribution
5   in the conventional vapor phase growth apparatus, obtained by a computer simulation.

BEST MODES FOR CARRYING OUT THE INVENTION

10   Paragraphs below will explain best modes for carrying out this invention, referring to the attached drawings.

FIGs. 1 to 4 schematically show an exemplary vapor phase growth apparatus 1 of this invention, allowing vapor phase growth of a silicon single crystal film on the main surface of a silicon single
15   crystal substrate to proceed therein.   FIG. 1 is a sectional side elevation of the apparatus, FIG. 2 is a partially enlarged view of FIG. 1, FIG. 3 is a plan view of the vapor phase growth apparatus 1, and FIG. 4 is an exploded perspective view showing, in a partially cut-off manner, an essential portion of the vapor phase growth apparatus 1
20   shown in FIG. 1. · As shown in FIG. 1, the vapor phase growth apparatus 1 has a reaction vessel 2 having a gas introducing port 21 formed on a first end 31 side in the horizontal direction, and has a gas discharging port 36 on a second end 32 side of the same direction.   The apparatus is configured so as to introduce a source
25   gas G for forming the film through the gas introducing port 21 into

the reaction vessel 2, to allow the gas to flow in the direction along

the main surface of a substrate W held in a near-horizontally

rotating manner in an inner space 5 of the reaction vessel 2, and to

discharge the gas from the gas discharging port 36 through an

5   exhaust duct 7.   The exhaust duct 7 configures an evacuation

system of the vapor phase growth apparatus 1, together with a

pressure-reducing pump RP (FIG. 3).

As shown in FIG. 1, in the inner space 5 of the reaction

10   vessel 2, there is disposed a disc-formed susceptor 12 rotatively

driven by a motor 13 around a vertical axis of rotation O, and only a

single slice of substrate W for fabricating a silicon epitaxial wafer is

disposed in a shallow spot facing 12b formed on the top surface of

the susceptor 12.   That is, the vapor phase growth apparatus 1 is

15   configured as a single-wafer-type apparatus.   The substrate W

typically has a diameter of 100 mm or larger.   On the upper and

lower sides of the reaction vessel 2, infrared heating lamps 11 for

heating the substrate are disposed at regular intervals

corresponding to the region where the substrate W is placed.

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In the internal space 5 of the reaction vessel 2, a bank

component 23 is disposed so as to surround the susceptor 12, as

shown in FIG. 3.   The bank component 23 is disposed so as to

align a top surface 23a thereof at an almost same level with a top

25   surface 12a of the susceptor 12 (and consequently the main surface

of the substrate W), as shown in FIG. 2. The gas introducing port
21 is opened, as shown in FIG. 1, so as to oppose to an outer
peripheral surface 23b of the bank component 23, so as to allow the
source gas G supplied through the gas introducing port 21 to collide

5   against the outer peripheral surface 23b of the bank component 23,
and to climb up onto the top surface 23a side thereof, and then to
flow along the main surface of the substrate W on the susceptor 12,
as shown in FIG. 2 or FIG. 4. In this embodiment, the outer
peripheral surface 23b of the bank component 23 is configured as a

10 cylindrical surface conforming to the geometry of the susceptor 12.
Along the inner periphery of the bank component 23, a plate-formed
preheating ring 22 for soaking is disposed, wherein the top surface
12a of the susceptor 12 disposed inside thereof is aligned at an
almost same level with a top surface 22a (see FIG. 2) of the

15 preheating ring 22. In the inner space 5, there is also disposed an
upper lining component 4 having a diameter almost same as that of
the bank component 23, at a position opposing to the bank
component 23. Both of the bank component 23 and the upper
lining component 4 are ring-formed components made of a quartz

20 material.

In the vapor phase growth apparatus 1, as shown in FIG. 1, a
virtual center line along the direction of flow of the source gas G,
extending from the first end 31 of the reaction vessel 2 towards the

25 second end 32, while crossing normal to the axis of rotation O of the

susceptor 12, is assumed as a horizontal standard line HSL.   The direction normal to both of the horizontal standard line HSL and the axis of rotation O of the susceptor 12 is assumed as a width-wise direction WL (FIG. 3).

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As shown in FIG. 3, gas introducing components 24R, 24L, introducing the source gas G supplied through gas introducing ports 21A, 21B towards the outer peripheral surface 23b of the bank component 23, are disposed between the gas introducing port 21

10   (21A, 21B) and the bank component 23 as being symmetrically distributed with respect to the horizontal standard line HSL on both sides thereof (more specifically, on the left and right of a pillar 33 of the reaction vessel 2).   The gas introducing components 24R, 24L are further provided with, in each of gas introducing spaces 240,

15   240 (FIG. 4) formed inside thereof, gas-introducing-component-side partition plates 34R, 34L further partitioning the flow of the source gas G in the width-wise direction WL.   By such configuration, the gas introducing spaces 240, 240 are divided into gas introducing spaces 24T, 24T closer to the horizontal standard line HSL and

20   spaces 24S, 24S more distant from the horizontal standard line HSL.

On the other hand, on the outer peripheral surface 23b of the bank component 23, as shown in FIG. 3, there are disposed

25   bank-component-side partition plates 35R, 35L partitioning the flow

of the source gas G into a plurality of streams in the width-wise direction WL, as being symmetrically distributed with respect to the horizontal standard line HSL. The source gas G tends to escape in the width-wise direction WL when the source gas G climbs up onto

5 the top surface 23a of the bank component 23. Provision of the bank-component-side partition plates 35R, 35L together with the above-described, gas-introducing-component-side partition plates 34R, 34L is successful in controlling the flow of the source gas G in the width-wise direction WL. In this embodiment, the

10 bank-component-side partition plates 35R, 35L are disposed one by one on both sides of the horizontal standard line HSL. Therefore, a resultant mode of disposition is such as having the gas-introducing-component-side partition plates 34R, 34L and the bank-component-side partition plates 35R, 35L respectively aligned

15 in the same plane in parallel with the horizontal standard line HSL and the axis of rotation O.

As shown in FIG. 3, the gas introducing ports 21A, 21B are formed so as to correspond with the gas introducing components

20 24R, 24L, respectively. A gas duct 50 branches into an inner duct 53 supplying the gas towards the gas introducing spaces 24T (FIG. 4) closer to the horizontal standard line HSL and an outer duct 51 supplying gas towards the gas introducing spaces 24S (FIG. 4) more distant from the horizontal standard line HSL, allowing

25 independent control of flow rate of the source gas G respectively by

mass flow controllers (MFC) 54, 52.   It is also allowable herein to

use manual valves in place of the MFCs 54, 52.   The inner duct 53

and the outer duct 51 are further divided into branched ducts 56, 56

and branched ducts 55, 55, respectively, having inner gas

5   introducing ports 21A, 21A and outer gas introducing ports 21B, 21B

opened on both sides of the horizontal standard line HSL.

As shown in FIG. 4, the gas introducing components 24R,

24L are quartz-made cylindrical components each having an oblong

10   section, and being opened respectively on the gas introducing port

21 side and on the bank component side 23.   The

gas-introducing-component-side partition plates 34R, 34L are

disposed respectively in the individual inner spaces of the gas

introducing components 24R, 24L, so as to extend from top plates

15   24a to bottom plates 24b disposed nearly in parallel with each other.

By virtue of such disposition of the gas introducing components 24R,

24L, integrated with the gas-introducing-component-side partition

plates 34R, 34L, in a detachable manner with respect to the

reaction vessel 2, any alteration for example of location of the

20   gas-introducing-component-side partition plates 34R, 34L can

readily be accomplished simply by exchanging the gas introducing

components 24R, 24L.

As shown in FIG. 3, a baffle 26 is disposed between the gas

25   introducing ports 21A, 21B and the gas introducing component 24R,

24L.　The baffle 26 is formed with an oblong geometry corresponded to the openings of the gas introducing components 24R, 24L as shown in FIG. 4, and has a plurality of gas passage holes 26a formed therein at regular intervals in the longitudinal

5　direction.　The gas passage holes 26a are formed at positions not interfering the gas-introducing-component-side partition plates 34R, 34L.　As shown in FIG. 3, a discharge-side gas guiding component 25 is disposed between the bank component 23 and the gas discharging port 36.

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　　The bank component 23 has a bow-formed cut-off portion 23k, as shown in FIG. 4, formed by notching the outer peripheral portion of the top surface 23a of the bank component 23 in a recess-forming manner, in a sector opposing to the gas introducing

15　components 24R, 24L.　The side face of the cut-off portion 23k forms a part of the outer peripheral surface 23b of the bank component 23.　The reaction vessel 2 is composed of a lower vessel 2b and an upper vessel 2a as shown in FIG. 1, and the upper lining component 4 and the bank component 23 are disposed along

20　the inner peripheral surfaces of the upper vessel 2a and a lower vessel 2b, respectively.　As shown in FIG. 2, a lower surface 23c of the cut-off portion 23k is aligned at an almost same level with an extension of the inner surfaces of the bottom plates 24b of the gas introducing components 24R, 24L, and plays a role of a gas

25　introducing surface.　The source gas G collides against the side

face 23b of the cut-off portion 23k, and climbs up onto the top surface 23a.

As shown in FIG. 2, the upper lining component 4 has a step

5   portion 4d composed of a first lower surface 4a opposing parallel to the top surface 23a of the bank component 23, an inner peripheral surface 4b opposing to the side face 23b (outer peripheral surface of the bank component 23) of the cut-off portion 23k, and a second lower surface 4c opposing in parallel with the lower surface 23c of

10 the same, so as to form, between itself and the cut-off portion 23k, a gas introducing gap 60 having a crank-shape section.   That is, the gas introducing gap 60 is a gas passageway formed by opposing the bank component 23 and the upper lining component 4.   As shown in FIG. 4, the bank-component-side partition plates 35R, 35L

15 are formed to be almost L-shaped conforming to the profile of the gas introducing gap 60.

FIG. 5 is a bottom plan view of the upper lining component 4 as viewed from the bank component 23 side.   The first lower

20 surface 4a and the second lower surface 4c opposing to the bank component 23 form the gas introducing gap 60.   The length-to-be-formed of the gas introducing gap 60 in the parallel direction to the horizontal standard line HSL is set depending on the degree of overlapping of the upper lining component 4 and the bank

25 component 23 in the vertical direction.   The vapor phase growth

apparatus 1 of this invention is configured so as to gradually reduce the length-to-be-formed as distanced from the horizontal standard line HSL in the width-wise direction WL.

5   FIG. 6A is a 6A-6A section containing the horizontal standard line HSL shown in FIG. 5, FIG. 6B is a 6B-6B section, and FIG. 6C is a 6C-6C section. In this embodiment, the length-to-be-formed of the gas introducing gap 60 is adjusted based on dimension of an inner periphery 40p of the lower surface 4a of the upper lining

10   component 4, located on the upstream side, in the direction of flow of the source gas G, rather than the inner periphery 23p of the top surface 23a of the bank component 23. In other words, as is clear from FIG. 6A, FIG. 6B and FIG. 6C when viewed in this order, the degree of overlapping, in the vertical direction, of the top surface

15   23a of the bank component 23 forming the gas introducing gap 60 and the lower surface 4a of the upper lining component 4 forming the same decreases as distanced from the horizontal standard line HSL in the width-wise direction WL. The length-to-be-formed of the gas introducing gap 60 in the direction along the horizontal

20   standard line HSL thus gradually decreases. Assuming now the lengths-to-be-formed appear in the 6A-6A section, the 6B-6B section and the 6C-6C section as D_A, D_B and D_C, respectively, a relation of $D_A > D_B > D_C$ is true.

As shown in the individual sectional views in FIG. 6A, FIG.
6B and FIG. 6C, an outer periphery 23q of the bank component 23
and an outer periphery 40q of the upper lining component 4 are
vertically aligned on the entrance side for the source gas G of the
5   gas introducing gap 60.   This configuration facilitates connection
of the gas introducing components 24R, 24L as the gas
passageways to the bank component 23 and the upper lining
component 4, without generating gaps therebetween.

10   FIG. 7 is a projected plan view showing an area of formation
of the gas introducing gap 60.   In FIG. 7, the gas introducing gap
60 is expressed by a hatched portion.   As shown in FIG. 7, on the
entrace side of the gas introducing gap 60, an arc drawn by the
outer periphery 23q of the bank component 23 and an arc drawn by
15   the outer periphery 40q of the upper lining component 4 coincides in
the vertical direction (direction along the axis of rotation O of the
susceptor 12).   In other words, both arcs have the same radius R_2.
The center of an arc having radius R_2 coincides with the axis of
rotation O of the susceptor 12.   On the other hand, on the exit side
20   of the gas introducing gap 60, the center of an arc having radius R_1
drawn by the inner periphery 23p of the top surface 23a of the bank
component 23 coincides with the axis of rotation O of the susceptor
12, but the center O' of an arc having radius R_3 drawn by the inner
periphery 40p of the lower surface 4a of the upper lining component
25   4 is set on the downstream side, in the direction of flow of the

source gas G, rather than the axis of rotation O of the susceptor 12. The radii of the individual arcs are in a relation of $R_1 < R_3$.

This embodiment showed an exemplary case where the length-to-be-formed of the gas introducing gap 60 gradually decreased as distanced from the horizontal standard line HSL, wherein it is also preferable to adopt another mode of configuration, as schematically shown in FIG. 9, wherein the length-to-be-formed of the gas introducing gap 60 is remained constant D_0 at any position as distanced from the horizontal standard line HSL in the width-wise direction WL.   It is, of course, possible to adjust the dimension of the upper lining component 4 as the length-to-be-formed of the gas introducing gap 60 step-wisely decreases.

The vapor phase growth apparatus 1, as viewed from another point of view, has a configuration as described below. That is, as shown in FIG. 7, on the entrance side of the gas introducing gap 60 (hatched portion), the outer periphery 23q of the bank component 23 and the outer periphery 40q of the upper lining component 4 coincide with each other in the vertical direction (direction along the axis of rotation O of the susceptor 12).   On the other hand, on the exit side of the gas introducing gap 60, the center of the arc having radius R_1 drawn by the inner periphery 23p of the top surface 23a of the bank component 23 coincides with the

axis of rotation O of the susceptor 12, and the center O' of the arc having radius R_3 drawn by the inner periphery 40p of the lower surface 4a of the upper lining component 4 is set on the horizontal standard line HSL on the downstream side, in the direction of flow of

5 the source gas G, rather than the axis of rotation L of the susceptor 12. Radii of the individual arcs are adjusted so as to satisfy a relation of $R_1 < R_3$. According to this configuration, the source gas G becomes less likely to deflect towards the horizontal standard line HSL over the top surface 23a of the bank component 23, as

10 compared with the conventional vapor phase growth apparatus.

Paragraphs below will describe a method of fabricating an epitaxial wafer using the above-described vapor phase growth apparatus 1. As shown in FIGs. 1 to 4, the substrate W is placed

15 on the susceptor 12 in the reaction vessel 2, subjected to a pretreatment such as removal of a native oxide film if necessary, and heated under rotation to a predetermined reaction temperature using infrared heating lamps 11. While keeping the condition unchanged, the source gas G is allowed to flow through the

20 individual gas introducing ports 21A , 21B into the reaction vessel 2 at a predetermined flow rate, so as to proceed epitaxial growth of a silicon single crystal film on the substrate W, to thereby obtain an epitaxial wafer.

The source gas G is used for the vapor phase growth of the silicon single crystal film on the substrate W, and is selected from silicon compounds such as $SiHCl_3$, $SiCl_4$, SiH_2Cl_2, SiH_4 and so forth. The source gas G is appropriately compounded with B_2H_6 or PH_3 as

5   a dopant gas, or with H_2 as a dilution gas, or the like.   For the case where the native oxide is removed in advance of the vapor phase growth of the film, a pretreatment gas prepared by diluting a corrosive gas such as HCl with a dilution gas is supplied into the reaction vessel 2, or the substrate W is subjected to

10   high-temperature annealing in a H_2 atmosphere.

Operations expectable during the flow of the source gas G in the reaction vessel 2 will be explained below.   As indicated by the dashed line with an arrow head in the plan view of FIG. 3, the

15   source gas G flows through the baffle 26 and the gas introducing components 24R, 24L towards the outer peripheral surface 23b of the bank component 23.   The source gas collided against the outer peripheral surface 23b then climbs up onto the top surface 23a of the bank component 23, and flows along the main surface of the

20   substrate W.   An exhaust gas EG is collected by a discharge-side gas guiding component 25 into the discharge duct 7, and then discharged.

Flow route of the source gas G in the conventional vapor.

25   phase growth apparatus will be explained referring to the drawing

for explaining operations shown in FIG. 8.   In the conventional

vapor phase growth apparatus, the source gas G advances via a

preheating ring onto a susceptor, while showing a tendency of

deflecting towards the center of the substrate and approaching the

5   horizontal standard line HSL.   This is because the source gas G

tends to flow in the direction possibly minimizing the resistance,

when it passes through the gas introducing gap 60' (hatched

portion) formed by a bank component 23' and an upper lining

component 4'.   Linear path d2 of the source gas G passing through

10   the gas introducing gap 60' is larger than shortest path d1 directed

to the center of the substrate.   In other words, the resistance

exerted on the source gas G advancing towards the susceptor 12

can be minimized, if the gas passes over a top surface 23a' of the

bank component 23' along the shortest path d1.   Because the bank

15   component 23' and the upper lining component 4' of the

conventional vapor phase growth apparatus have ring-like

geometries with the same diameter, linear path d2 becomes longer

as more distanced from the horizontal standard line HSL.   As a

consequence, stream of the source gas G flowing more distant from

20   the horizontal standard line HSL, or more closer to the both edge

regions in the width-wise direction WL, more largely varies the

direction of flow thereof over the top surface 23a' of the bank

component 23' towards the center of the substrate.

When the flow velocity of the source gas G is not so large, the gas after climbing over the bank component 23' is once directed towards the center of the substrate, but immediately changes the direction of flow into the downstream direction, due to an elevated

5   pressure in the vicinity of the horizontal standard line HSL where the streams concentrate.   Therefore, the event that the source gas G after climbing over the bank component 23' is once directed towards the center of the substrate will be of no critical issue, when the flow velocity of the source gas G is not so large.   On the

10   contrary, when the flow velocity of the source gas G is large, streams will not change their directions into the downstream direction up to positions showing the pressure elevated enough in the vicinity of the horizontal standard line HSL, where the streams concentrate.   In other words, the travel path towards the center of

15   the substrate grows longer.   As a consequence, the event that the source gas G after climbing over the bank component 23' is once directed towards the center of the substrate will result in a larger effect, when the flow velocity of the source gas G is large.

20   In the epitaxial growth of the silicon single crystal film in the reaction vessel having a pressure conditioned lower than the atmospheric pressure (so-called, reduced-pressure epitaxial growth), the flow velocity of the source gas G flowing through the reaction vessel is several times faster than in the normal-pressure

25   epitaxial growth.   Therefore, in particular in the reduced-pressure

epitaxial growth, the event that the source gas G after climbing over the bank component 23' is once directed towards the center of the substrate becomes not negligible.

5   In contrast to this, the vapor phase growth apparatus 1 of this invention is configured so that the length-to-be-formed of the gas introducing gap 60 is reduced as more distanced from the horizontal standard line HSL in the width-wise direction WL. According to this configuration, the phenomenon of a large change

10   in the direction of flow of the source gas G, towards the horizontal standard line HSL, becomes less likely to occur. The source gas G can therefore flow relatively straight towards the susceptor 12. This successfully ensures a uniform flow route over the substrate W.

15

Experimental Cases

(Computer Simulation Experiments)

A flow route of the source gas in the vapor phase growth

20   apparatus 1 as shown in FIGs. 1 to 4 was found by computer simulation. For the comparative purpose, also a flow route of the source gas in the conventional vapor phase growth apparatus having an unimproved upper lining component was found. Also a growth rate distribution of the silicon single crystal film when it was

25   epitaxially grown on the silicon single crystal substrate in the vapor

phase growth apparatus 1 shown in FIGs. 1 to 4 was estimated by computer simulation. For the comparative purpose, also a growth rate distribution of the silicon single crystal film when it was epitaxially grown on the silicon single crystal substrate in the

5 conventional vapor phase growth apparatus was estimated. Set conditions were as listed below.

Software: Fluent Ver 6.0 (product of Fluent Asia Pacific Co., Ltd.)
(Dimensions)

10 · Inner diameter of bank component= 300 mm
· R_3 of upper lining component (see FIG. 5)= 200 mm
· Height of reaction vessel (distance from the susceptor 12 to the inner top surface of the reaction vessel 2)= 20 mm
· Height of bank component (height measured from the lower

15 surface 23c of the cut-off portion 23k to the top surface 23a of the bank component 23)= 16 mm
· Diameter of silicon single crystal substrate= 200 mm
(Growth Temperature)
· Silicon single crystal substrate: 1400 K

20 · Top surface of reaction vessel : 700 K
(Pressure in Reaction Vessel)
· 10000 Pa
(Source Gas)
· Trichlorosilane: 1.5 mol%

25 · Hydrogen: 98.5 mol%

(Flow Rate of Source Gas)

· Inner Introduction Path: 13.5 L/min (standard state)

· Outer Introduction Path: 13.5 L/min (standard state)

5   FIGs. 10A and 10B are drawings showing the flow routes of the source gas G obtained by the computer simulation, and FIGs. 11A and 11B are contour maps showing growth rate distributions of the silicon single crystal film.   FIGs. 10A and 11A correspond to the cases using the vapor phase growth apparatus 1 of this invention, 10   and FIGs. 10B and 11B correspond to the cases using the conventional vapor phase growth apparatus.

        First as seen in FIG. 10A, the source gas in the vapor phase growth apparatus 1 of this invention shows only a small tendency of 15   approaching towards the center of the substrate (horizontal standard line HSL).   On the other hand, as shown in FIG. 10B, the source gas G in the conventional vapor phase growth apparatus shows a large inward deflection in the direction of flow over the top surface 23a of the bank component 23.

20

        The contour maps of the growth rate distribution as seen next in FIGs. 11A and 11B show the contours indicating slower growth rates as the flow advances towards the downstream side, because it is assumed herein that the silicon single crystal 25   substrate W is not rotated.   The contours in the conventional vapor

phase growth apparatus showed a large waving, whereas the contours in the vapor phase growth apparatus 1 of this invention were found to show only a small rippling.